



Armed Forces College of Medicine

AFCM



Cardiac Output

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INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the students will be able to:

- 1) Define stroke volume, cardiac output, and cardiac index
- 2) Explain the influence of altered preload on force of contraction of the cardiac muscle.
- 3) Describe the factors that help in venous return in upright position
- 4) Explain the role of contractility and after load in regulation cardiac output.
- 5) Describe the Indices of myocardial contractility

Cardiac Output



Definition:

- ✓ **Cardiac output is the amount of blood pumped from each ventricle in one minute.**
- ✓ **It equals 5 L/min in adult healthy man in supine position.**



Do cardiac output vary?



Yes it vary with

- 1. The basic level of body metabolism.**
- 2. The level of activity of the body.**
- 3. Exercise**
- 4. Age**
- 5. The body size.**
- 6. Pregnancy**
- 7. Body position standing or sitting.**

Some Important Definitions



Stroke Volume:

It is the amount of blood pumped by the ventricle in one beat.

End Diastolic volume:

It is the amount of blood present in each ventricle at the end of diastole.

End Systolic volume:

It is the amount of blood remaining in each ventricle at the end of systole.

Cardiac Index :

The cardiac index is the cardiac output per square meter of body surface area.

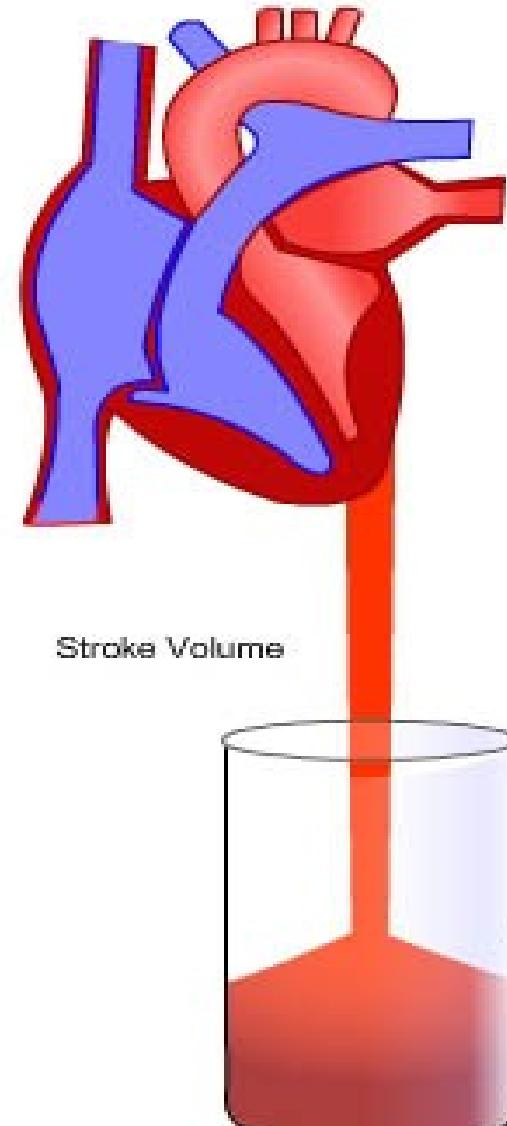
Ejection Fraction:

It is the ratio of stroke volume to end diastolic volume. It averages 60%.

Cardiac Output



Cardiac output=
Stroke volume ×
Heart rate

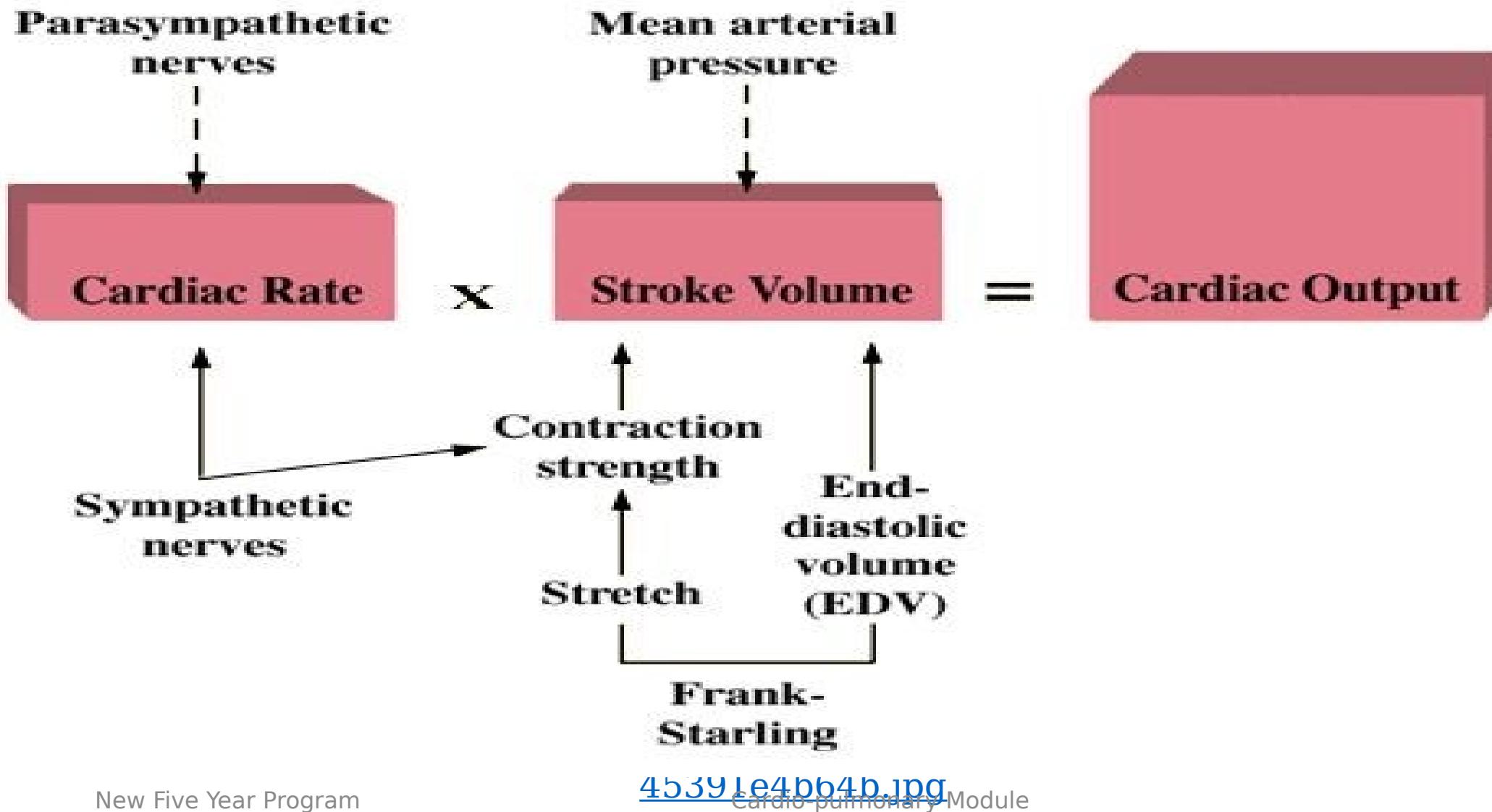


To increase cardiac output

Increase stroke volume
or

Increase heart rate
or
increase both

Cardiac Output Determinants

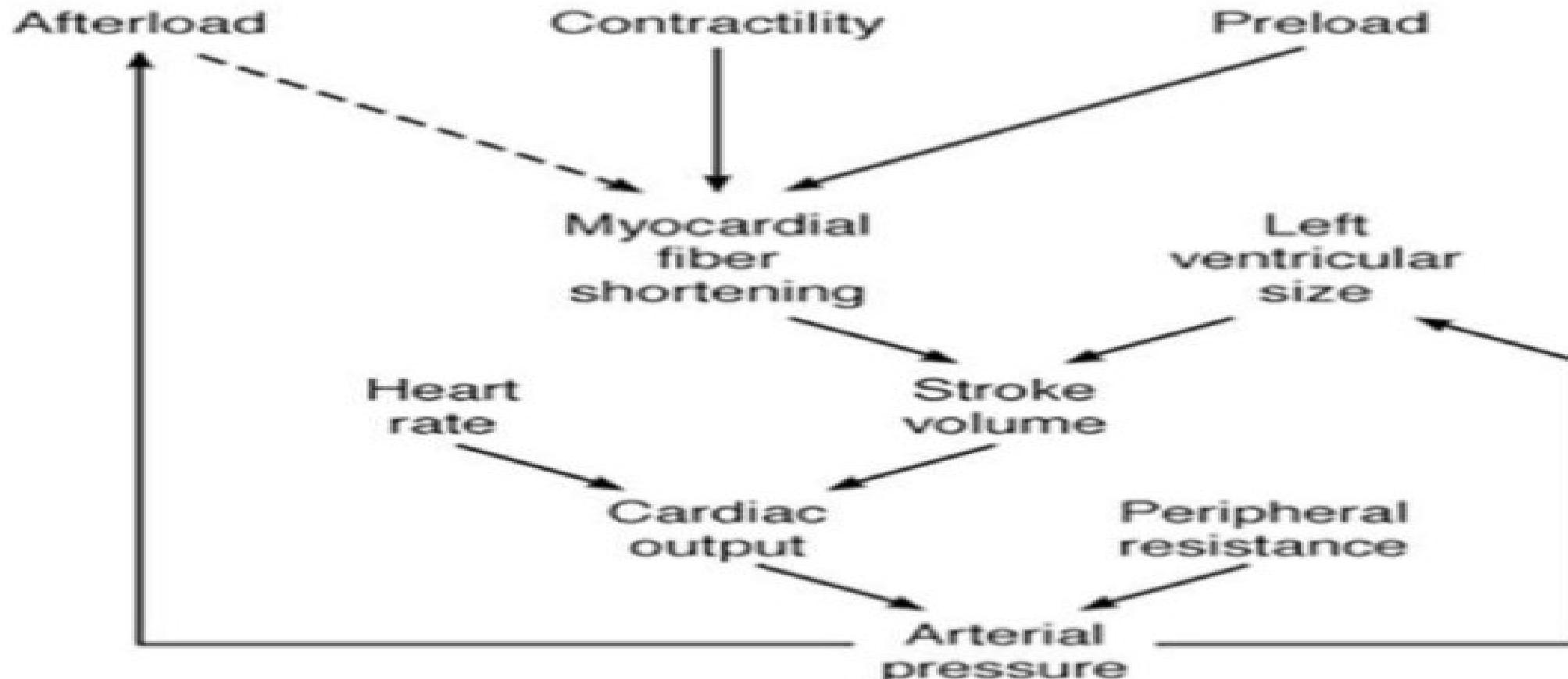


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Factors regulating cardiac output



Factors regulating Cardiac Output



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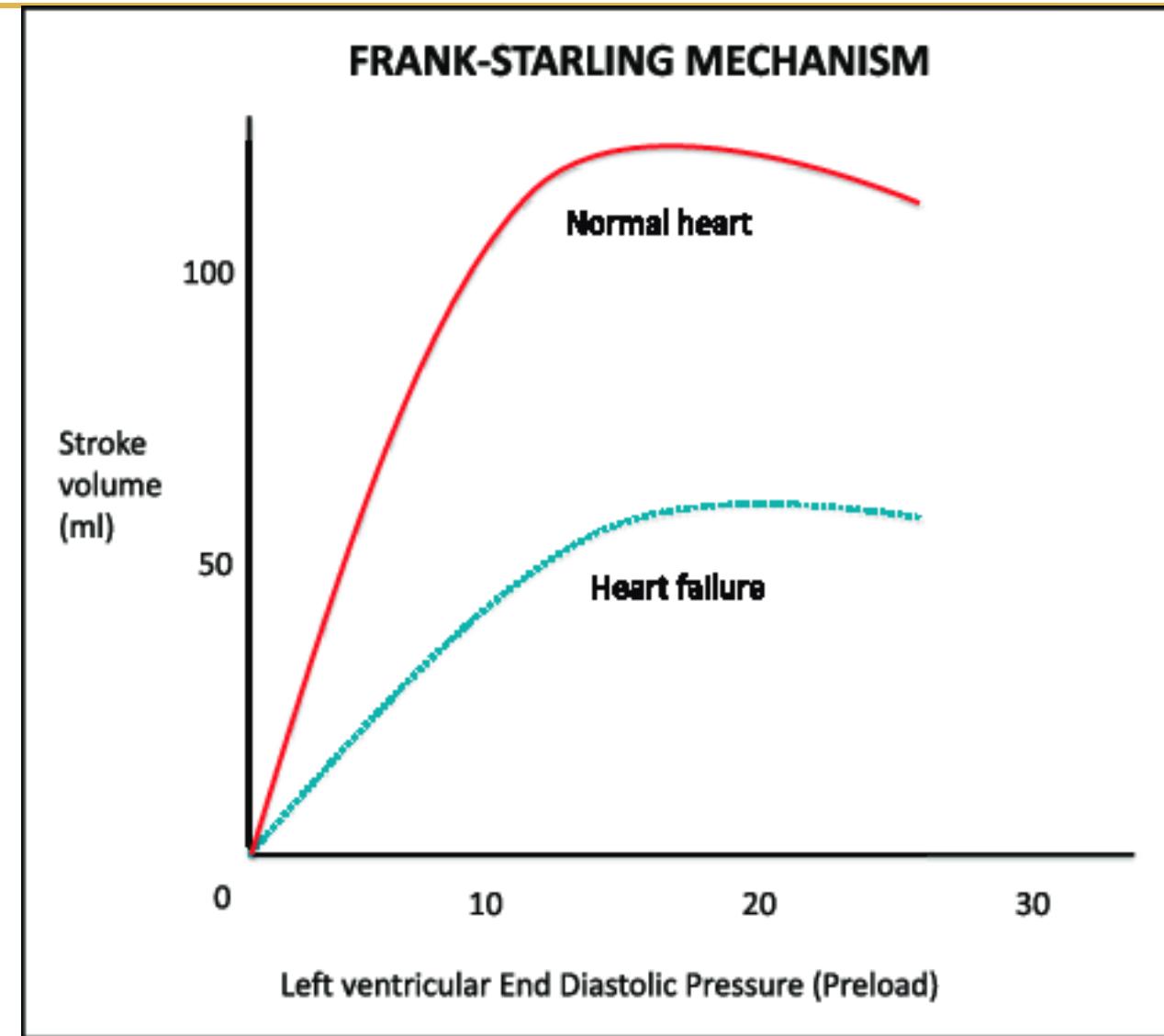
1) End Diastolic Volume

EDV= Preload, venous return, Heterometric regulation):

Stroke volume is increased with increased EDV due to:

Frank- Starling's law ??????

The length of the muscle
What about stretch of the end-diastolic volume.





End diastolic volume is affected by :

- 1. Venous return**
- 2. Systolic contractions of the ventricle**
- 3. Diastolic functions as increase in intrapericardial ...**
- 4. The total blood volume (Direct relationship):**

Factors helping venous return



**Capillary
Tone**

End-diastolic volume

**Valves of the
vein**

Venous return

**Negative
intrathoracic
pressure**

Blood volume

Venous pressure

Breathing

**Urine
volume**

**Tissue-fluid
volume**

Venoconstriction

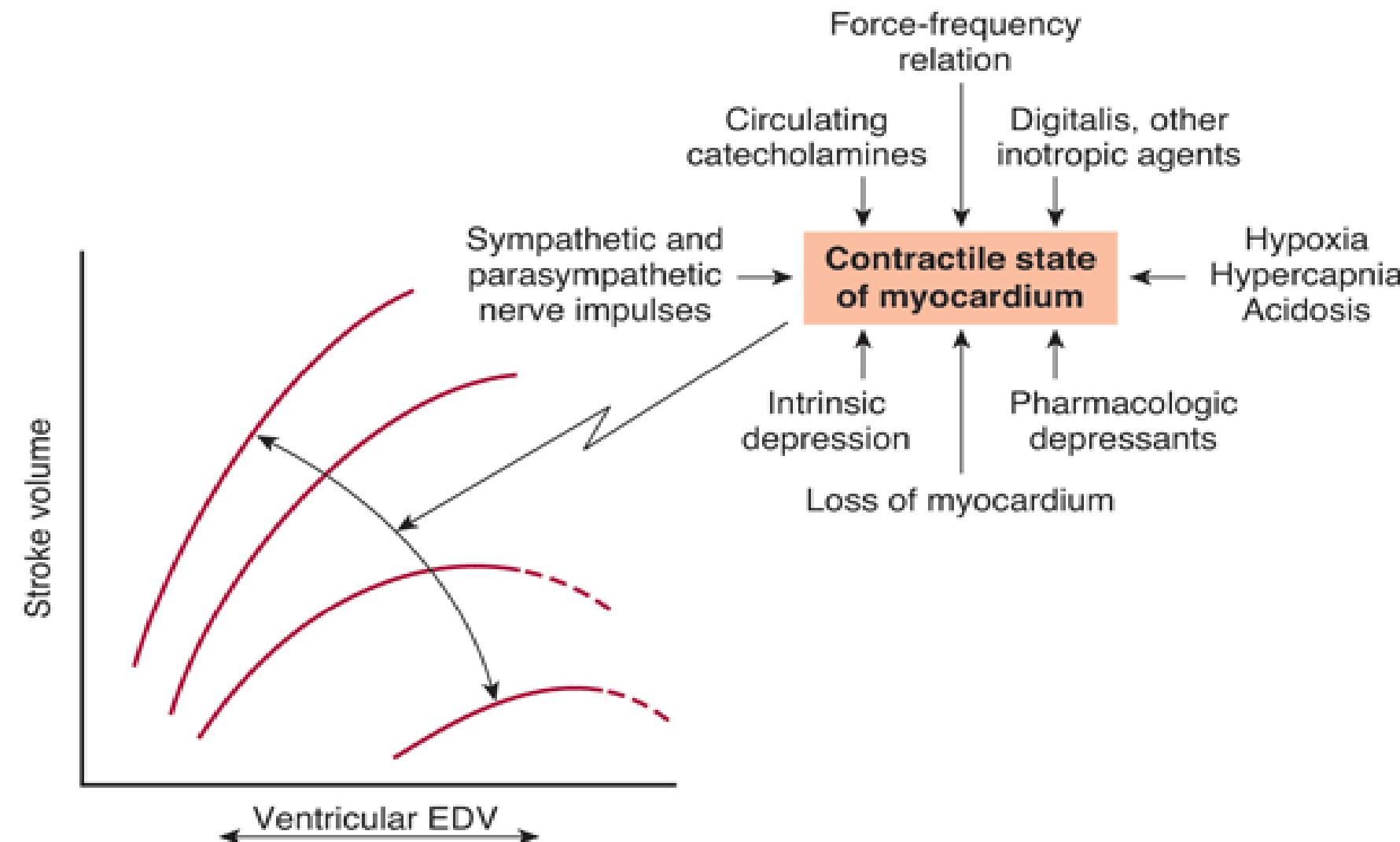
**Skeletal
muscle
pump**

**Sympathetic
nerve stimulation**

2) Myocardial Contractility



Regulation due to changes in contractility independent of length is sometimes called homomeric regulation.



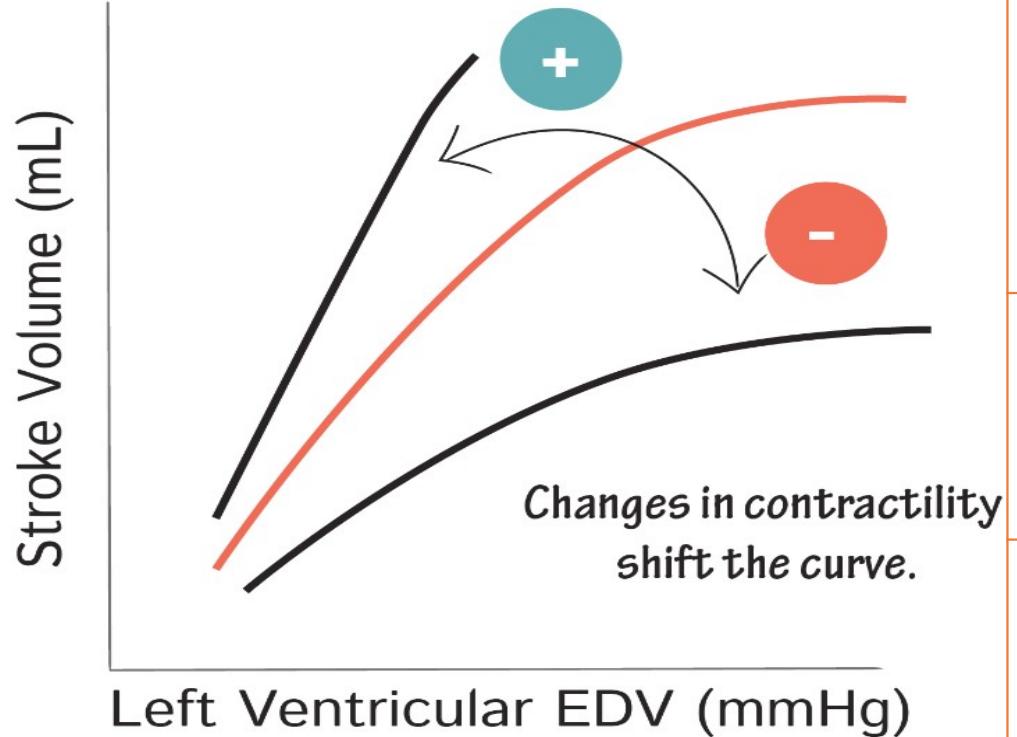
Source: Barrett KE, Barman SM, Boitano S, Brooks H: *Genung's Review of Medical Physiology*, 23rd Edition: <http://www.accessmedicine.com>

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Factors affecting contractility



Frank-Starling Law



<https://d1j63owfs0b5j3.cloudfront.net/term/images/682-1495202312416.png>

+ve inotropic factors

The sympathetic nervous system (β_1)

Circulating catecholamines (β_1)

Digitalis (inhibition of $\text{Na}^+ - \text{K}^+$ pump).

Increased heart rate due to increased

-ve inotropic factors

The parasympathetic nervous system (M2)

Intrinsic depression (heart failure)

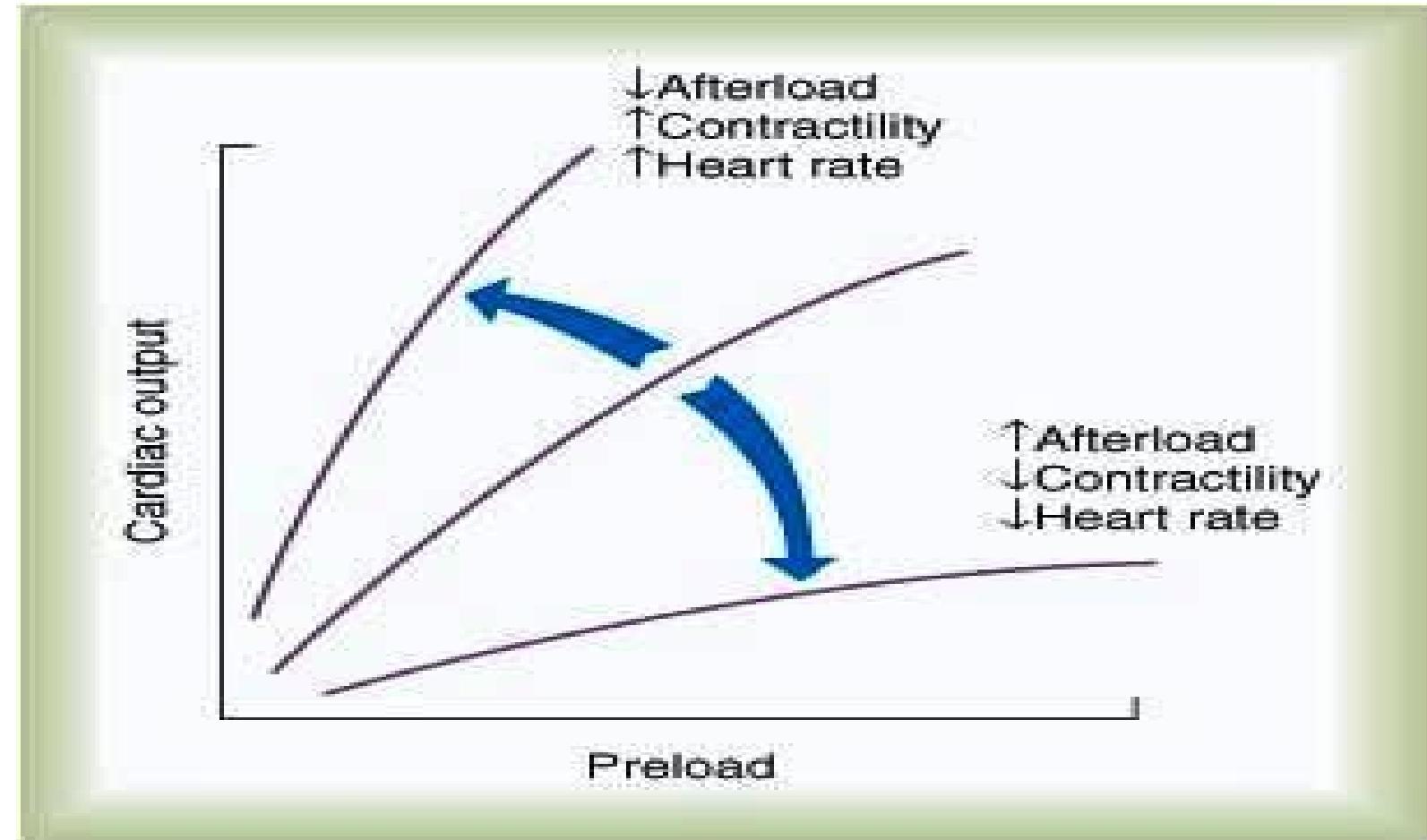
Loss of myocardium

Hypoxia and acidosis



3) Peripheral resistance

The cardiac output has reciprocal relationships with changes in total peripheral resistance



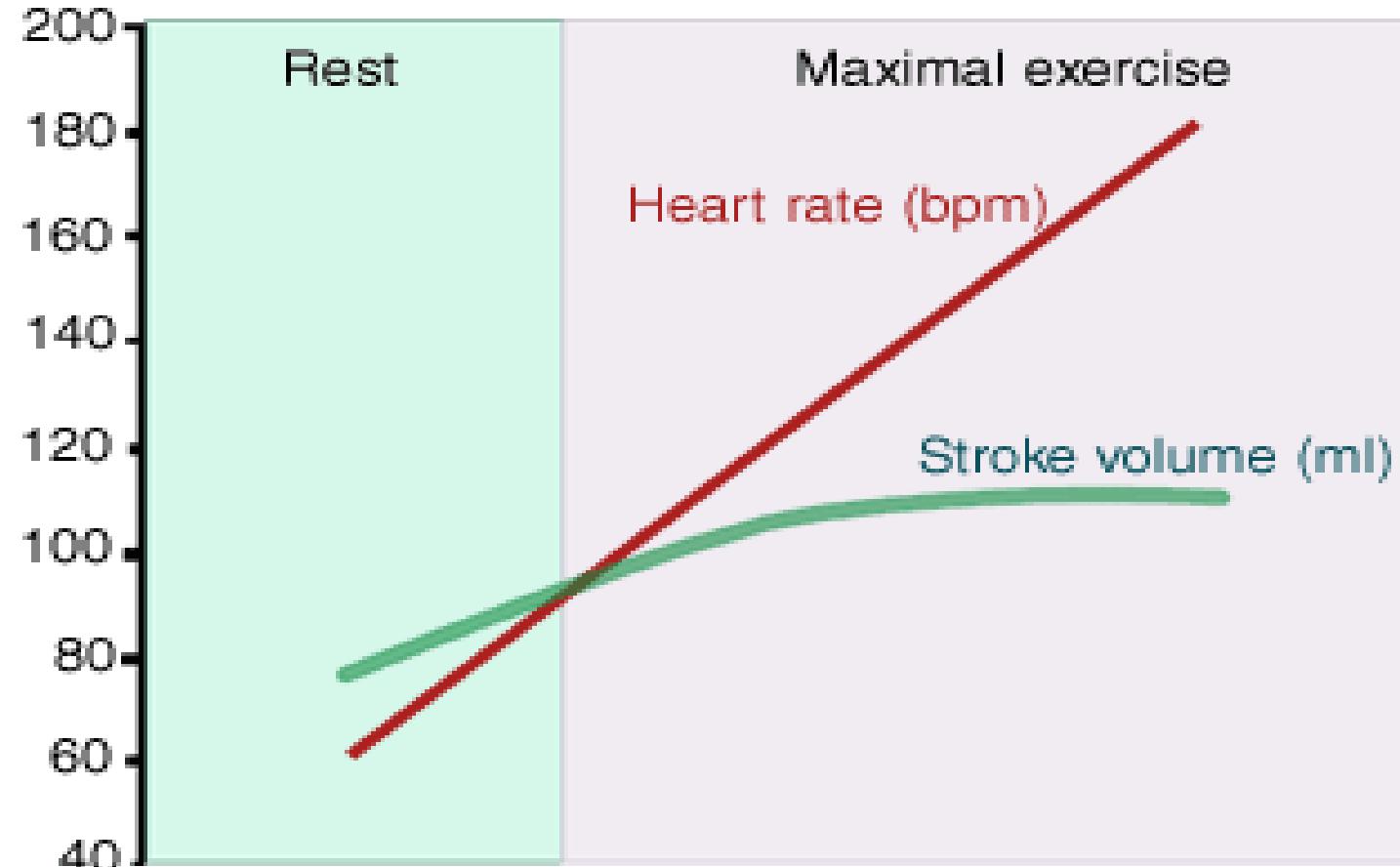
https://media.lanecc.edu/users/driscolln/RT127/Softchalk/Heart_Perfusion/pre%20and%20afterload.jpg



4) Heart rate

**Heart rate
has direct
proportion
to cardiac
output**

**What
happen
with **Very**
rapid heart
rate ?**

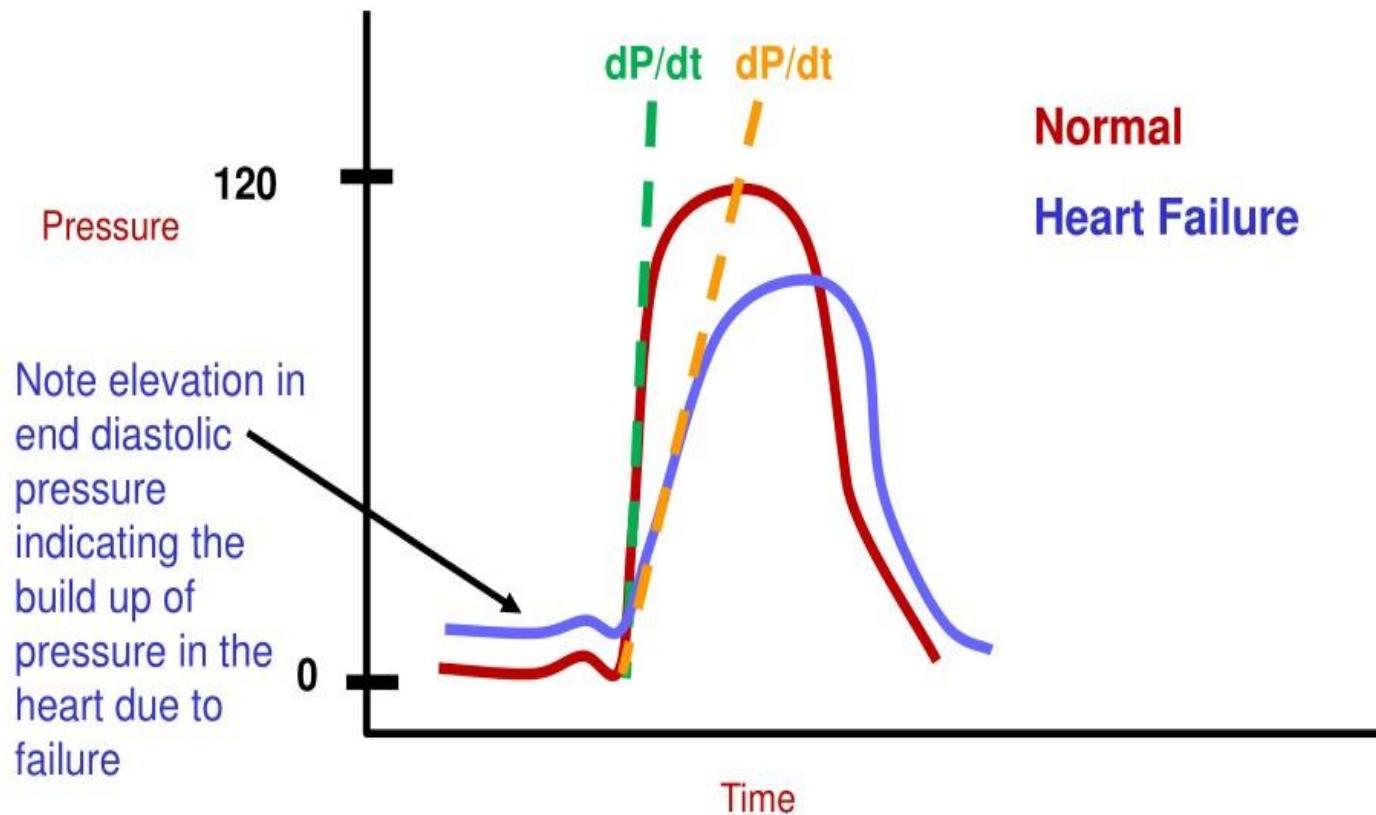


https://www.medicine.mcgill.ca/physio/vlab/exercise/img/heartrate_strvol.gif

Indices of Contractility

dp/dt

dP/dt = change in pressure per unit of time



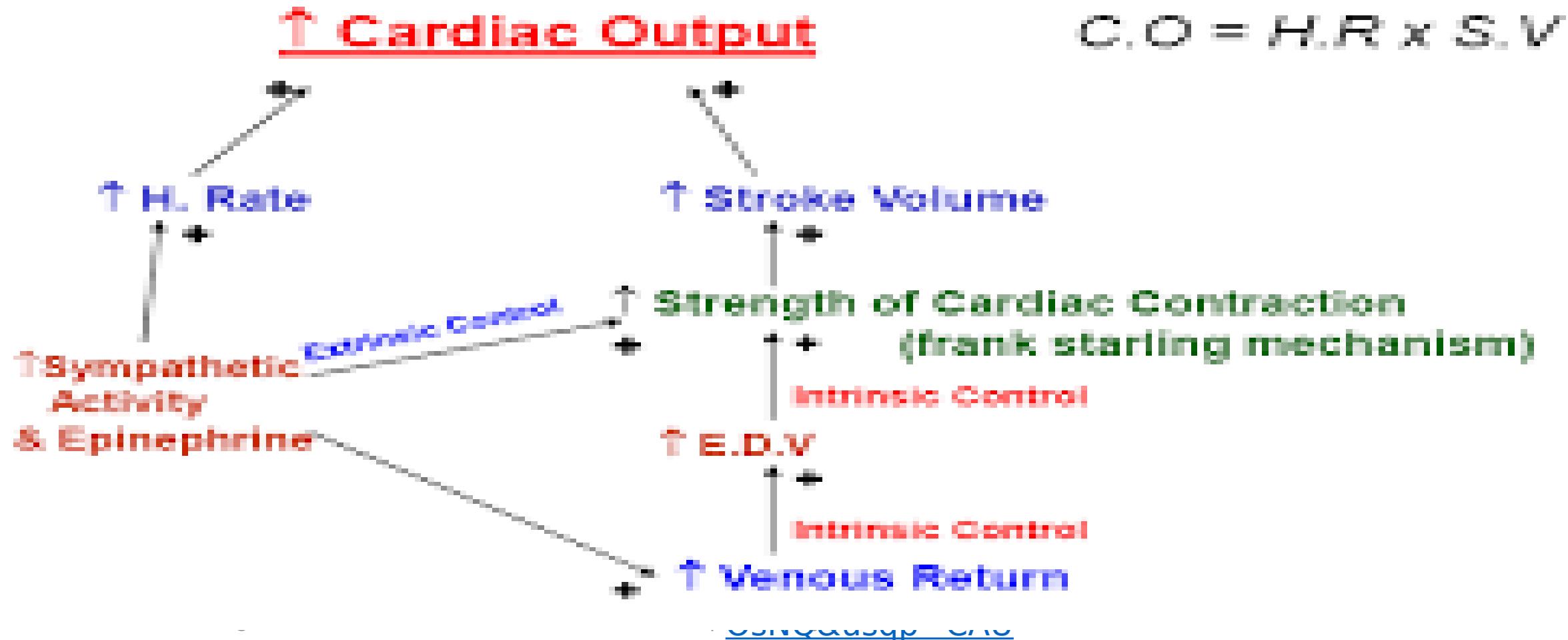
Ejection Fraction

Parameter	Males	Females
LVEF (%)	55-73	54-74
EDV (mL)	102-235	96-174
ESV (mL)	29-93	27-71
SV (mL)	66-148	62-110

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Regulation of Cardiac Output



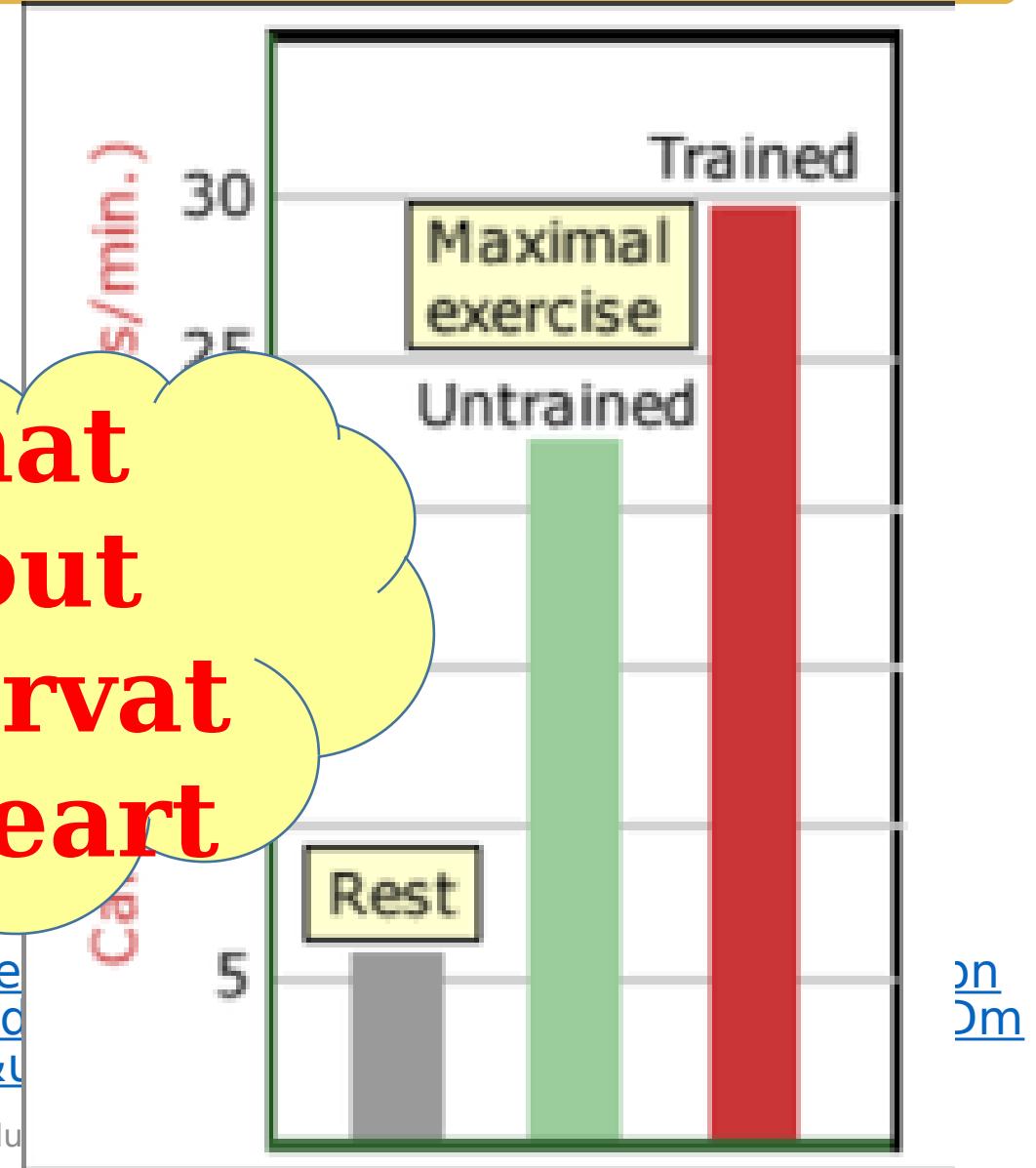
Cardiac Output in Exercise



- During exercise sympathetic stimulation increase
- circulating catecholamines????
- Muscle contraction during exercise and increase respiratory rate increase venous return, end diastolic volume and CO.
- Due to vasodilation of skeletal muscle blood vessels, peripheral

What about denervated heart

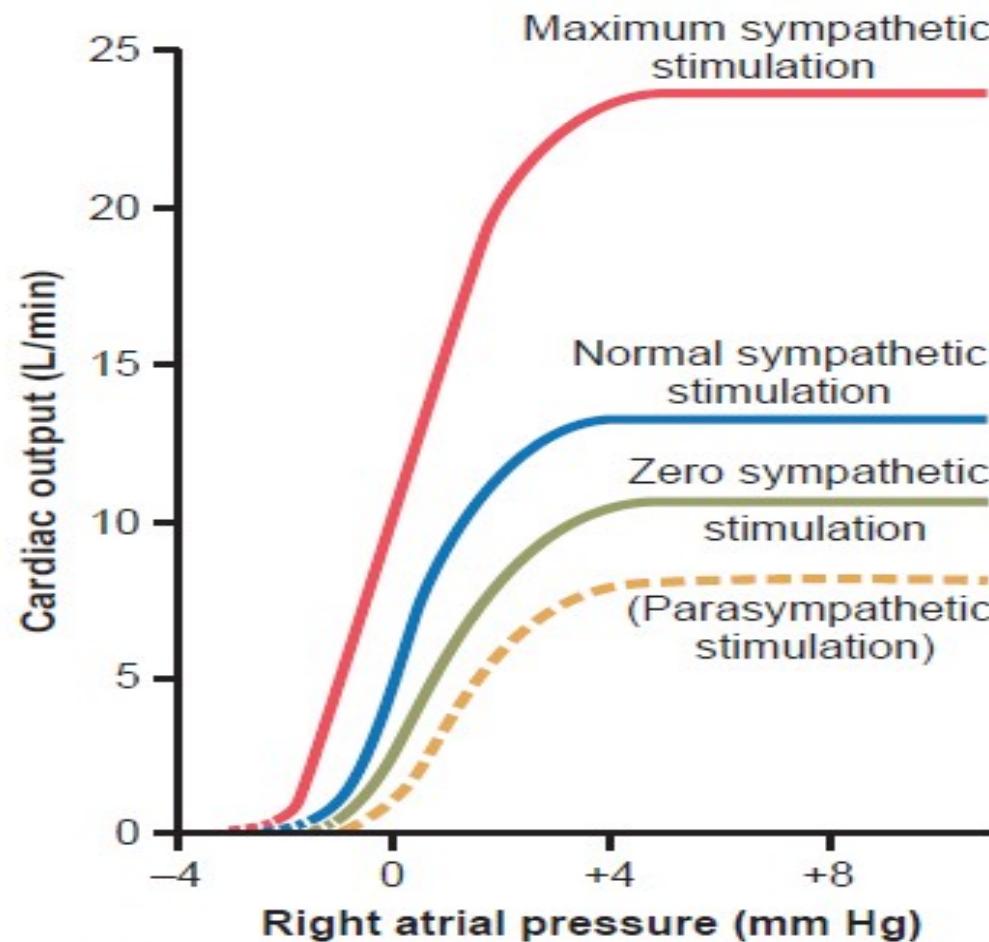
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Cardiac output and sympathetic stimulation



- Decrease systolic interval by increasing contractility and increased peak ventricular pressure.
- Decrease diastolic interval by increasing heart rate: as intracellular calcium is increased more than sequestrated calcium. So contractility increase



Lecture Quiz



Q1) Determinants of cardiac output are ?

- a) Stroke volume
- b) Heart rate

Q2) which of the following will not increase CO in exercise:

- a) Frank starling law .
- b) Increased heart rate
- c) Increased venous return
- d) Venodilation
- e) Sympathetic stimulation

d

SUGGESTED TEXTBOOKS



1. Ganong 23rd edition P 678 to P. 685
2. Guyton and Hall 13th edition P. 118. to P. 120



Thank you



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